Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/173
UNITED KINGDOM
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

THE PHYSICS OF THE DOUNREAY FAST REACTOR AT POWER

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The physics of the Dounreay Fast Reactor has been the subject of several papers which have covered the period from first criticality to operation at 11 MW. The present paper deals with physics problems of the reactor at power and extends the published work to the end of 1963.

A. Statics

A brief summary of recent modifications to D.F.R. is given. By comparing several calculations, using various computer codes and cross-section libraries, the critical mass of D.F.R. may be estimated to 1% in spite of its complex core. An assessment of the required accuracy is given. Measurement of reactor power and fuel rating is made in several ways which are compared and differences explained. The ^{238}U (n,γ) reaction rate in the radial blanket has been determined by radio-chemical analysis of irradiated bulk uranium (breeder elements) and small samples of powder. Agreement with calculation is within experimental error (10%). A significant improvement has been made in agreement between measured and calculated reaction rates near the core boundary by adopting a hexagonal model for the calculation. In order to increase the fission rate obtainable in experimental rigs in the radial blanket the effect of replacing the uranium by a number of materials was investigated. Replacement by steel has increased the ^{235}U fission rate by 15-25% and an additional gain of 1.3% reactivity was achieved. By experiments involving changes in coolant flow rate and

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reactor power it has been possible to evaluate the performance of the delayed neutron coolant monitors. With sealed fuel elements, it would be possible to detect the exposure to the coolant stream of a few square cm of enriched fuel. During shutdown for fuel replacement the neutron flux was monitored and variations were related to changes in the core loading. In one carefully conducted series of readings criticality after reloading was predicted to within 0.5%.

B. Kinetics

In the second part of the report the reactivity feedback calculations and measurements are described for charges 3 and 4. Reference is made to the oscillatory and steady state measurements of feedback and to transient response following ramp reactivity change. It is shown that the total amount of fast acting feedback is small after significant burn-up, because of the loss of the fuel axial expansion contribution. The measured responses on a slow time scale are in poor agreement with calculation mainly because the flow and temperature distributions are uncertain in the blanket region. However the kinetic behaviour is reasonably well understood in the region of most interest.

It is concluded that the oscillator measurements (together with the other feedback measurements) provide an extremely valuable guide to the understanding of the kinetic behaviour, and have revealed changes in the characteristics of the D.F.R. core which might not have been found otherwise.